MORS Workshop: Bringing Analytical Rigor to Joint Warfighting Experimentation: Design, Planning, Execution, Analysis and Reporting

Human Factors: Conducting Over the Shoulder Assessment for Military Exercises and Experiments

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3-5 October 2006

0

Exercise and JEFX Experience

- JEFX 1999 AFRL/HEA
  - Warfighter Operations Centers
- JEFX 2000, AFRL HEA & AFEO Assessment Team
  - CAOC Time Sensitive Targeting
- JEFX 2000, AFEO Assessment Team
  - JAOC Time Sensitive Targeting
  - Human Factors & Opns Effectiveness
- Schreiber I and II (Capt Del Vecchio)
  - SWC and SMC/XR (Transformation Div)
  - Weapon System Effectiveness
- Virtual Flags, AFRL-HEA
  - BCC-X Training Requirements
  - Operator Effectiveness
- JEFX 2004, ESC & AFEO Assessment Team
  - Battle Control Center-Experimental
  - Tactical Battle Management Command & Control
  - Human Factors/Ops Utility Assessments

1

Report Documentation Page

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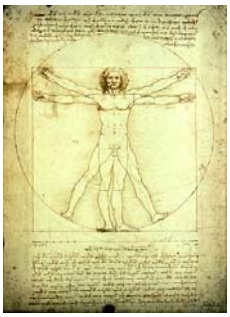
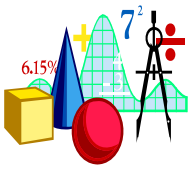
Agenda



- Introduction
- Human Factors Concepts
- Understanding Control



- JEFX Overview
- HF Assessment JEFX 02
- HF Assessment JEFX 04

2

A Story from the Field

- Nuclear power plant operators have to periodically go to simulator and pass a certification test
- Assessors evaluate performance to ensure that operators have the expertise that is required to operate the plant safely and effectively

3

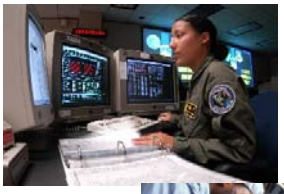
A Story from the Field

- **Frustrated by repeated "write-ups" for failure to comply with established procedure they decided to perform next simulation strictly "by the book"**
- **Un-amused, the assessors cited the operators for "*malicious compliance with procedures*"**

4

Role of Human Operator

The role of the ***human operator*** in today's complex socio-technical systems is to ***adapt*** to the unanticipated variability inherent in a dynamic ***operational environment***



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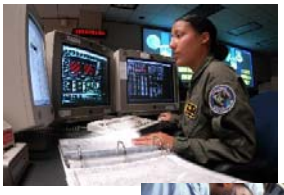
Role of Technology

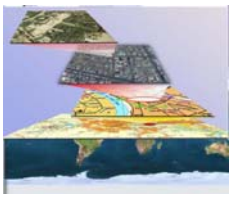
The role of the ***technology*** in these systems it so ***support*** the development and deployment of operators' ***adaptive strategies*** in the face a dynamic task environment




6

Defining Rigor: A Human-Centric Perspective

- **A OTS assessment is rigorous to the extent that it**
  - provides analysts with ***insight*** into and ***understanding*** of the mechanisms and strategies of human operators to ***adaptively cope*** with the complexities of a ***dynamic, uncertain, and high consequence*** operational environment.
  - demonstrates the extent to which technology, in all its forms, ***supports*** the ***coping strategies*** of human operators and enhances overall system performance.

7

Coping Strategies

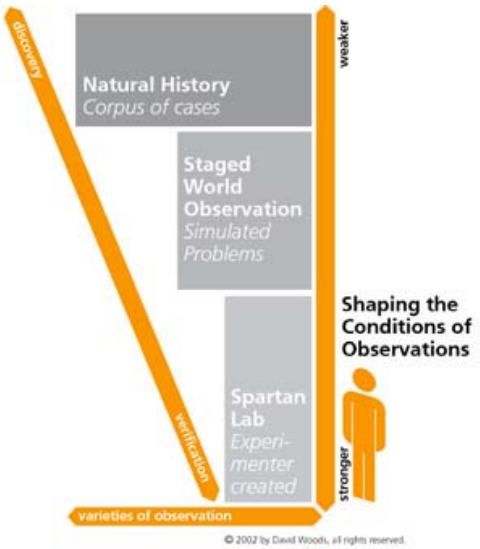
- **Accept reduced performance – all tasks will be performed but at lower performance levels**
- **Shed load – prioritize across tasks and activities, dropping out those considered low priority**
- **Redistribute work demands – shift work to other local/distributed operators or automated agents**
- **Reduce Operational Tempo – manage the processing tempo resulting in less work per unit time**

8

Shaping Conditions of Observation

"There is a need to orchestrate varieties of observation that are diverse in how they shape (and therefore distort) the processes we wish to observe and understand"

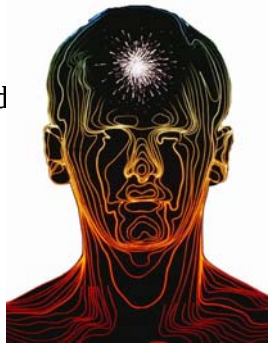
Woods & Hollnagel (2006)



9

What makes OTS Assessment difficult?

- Complexity of Operations: What do you look for?
- Context sensitivity: Every instance is different
- Goal conflicts: Avoiding goal fixation
- Distributed nature of work
- Observability: Getting inside the head
- Operator variability
- Process vs Product
- Plans vs Situated Action
- Metrics and measures



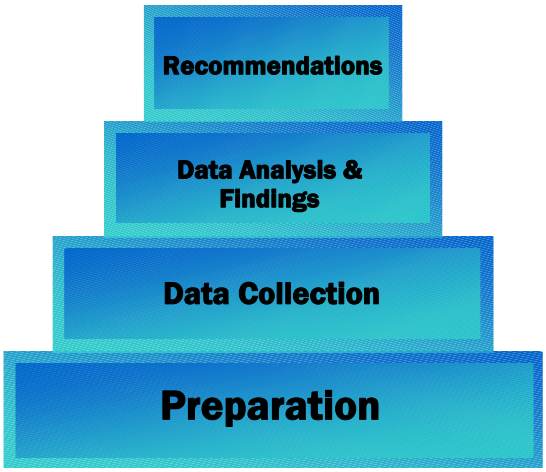
10

How can OTS support analytical rigor?

- Explain and substantiate (not just "what" but also "how" and "why")
- Avoid premature narrowing (iterative process of broadening and focusing)
- Exploit the dual status of prototypes
  - Tools for discovering new aspects of dynamic demands and constraints of operational domains (test our assumptions)
  - Hypotheses of what will be useful. Refined product to support operators in the pursuit of operational goals and objectives.

11

Lessons Learned from the Field: Best Practices for OTS Assessment



12

Preparation: Building Expectations

- **Literature Review**
  - **Doctrine**
  - **Test and Field Reports**
  - **Experimentation Plans**
  - **Concepts of Operations**
- **Technology CONOPS development**
  - **What purpose does technology serve (design intent)**
  - **Anticipate consequences of technology change**
  - **Establish expected outcomes**
  - **Develop conceptual model of the work system**
- **Scenario Generation**
  - **Participation in development of MSEL to enable anticipation of interesting situations and opportunities for data collection**

13

Data Collection and Observation

- Surveys
  - Use surveys to guide and direct observation
  - Identify specific challenging activities or things that will likely prove problematic
  - Leverage operational patterns seen across domains
  - Generate survey questions that will expose problem areas and unique challenges
- Observation
  - Capture unique aspects of operator behavior
  - Look for variations in strategies across operators
  - Record operators to extent possible to support follow-up sessions with operators
  - Think Aloud techniques
- Interviews
  - Follow-up sessions with operators to review critical incidence, provide more in-depth understanding of performance and task strategies

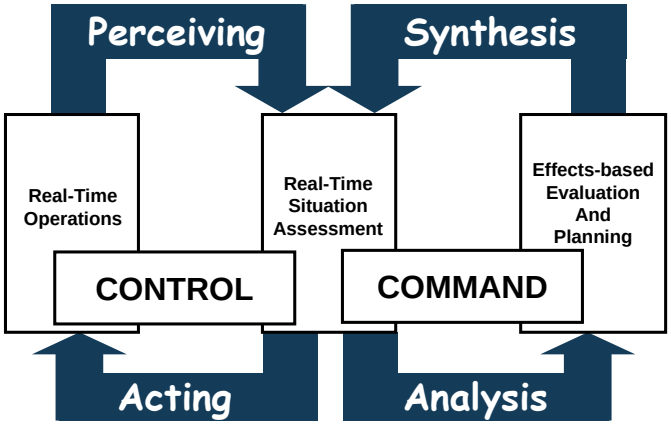
14

Data Analysis, Findings and Recommendations

- Pursuing causal explanations
  - Interpretation of data, why did we see what we saw
  - What was impact
- Identify how technology changes work
  - Mapping observation to expectations
    - In response to mission events
    - In response to technology
  - Identify unintended consequences of technology
- Refining models and assumptions
  - How did observation change expectations

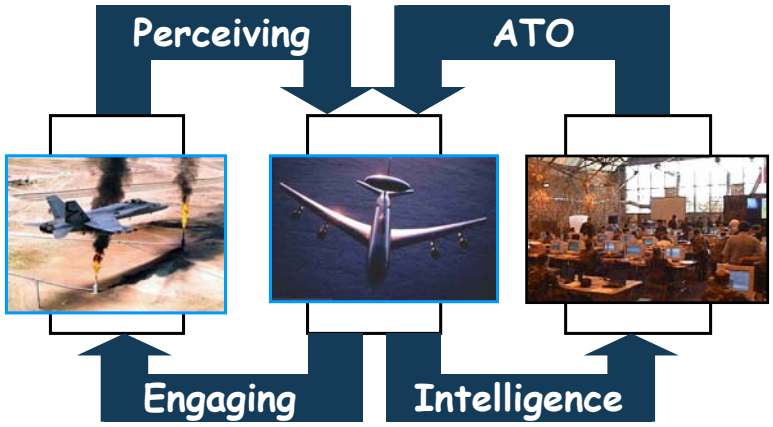
15

Understanding Adaptive Control



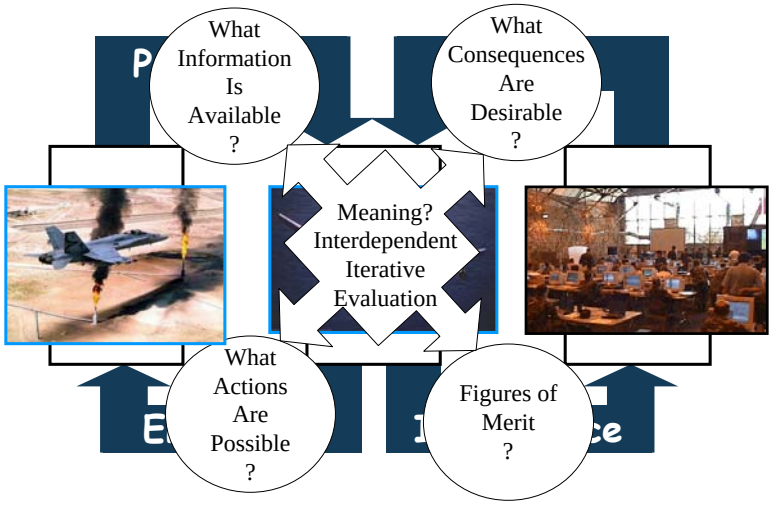
16

Combat Air Operations Example



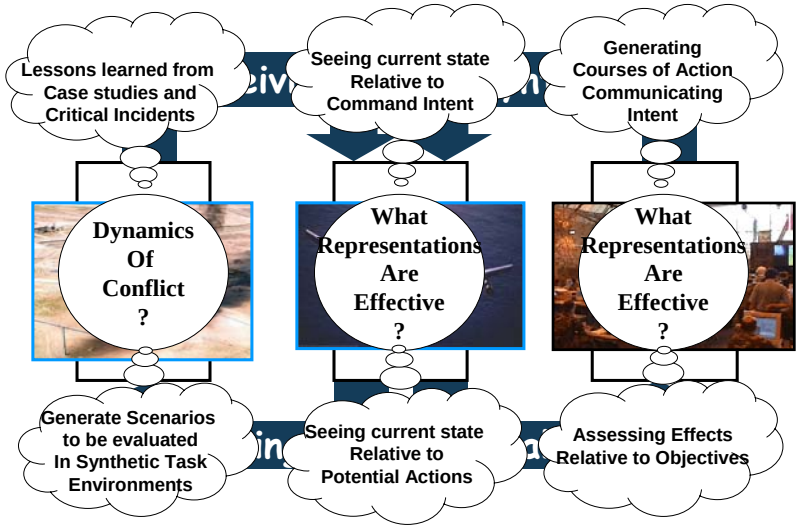
17

What information is pursued?



18

What Representations are useful?



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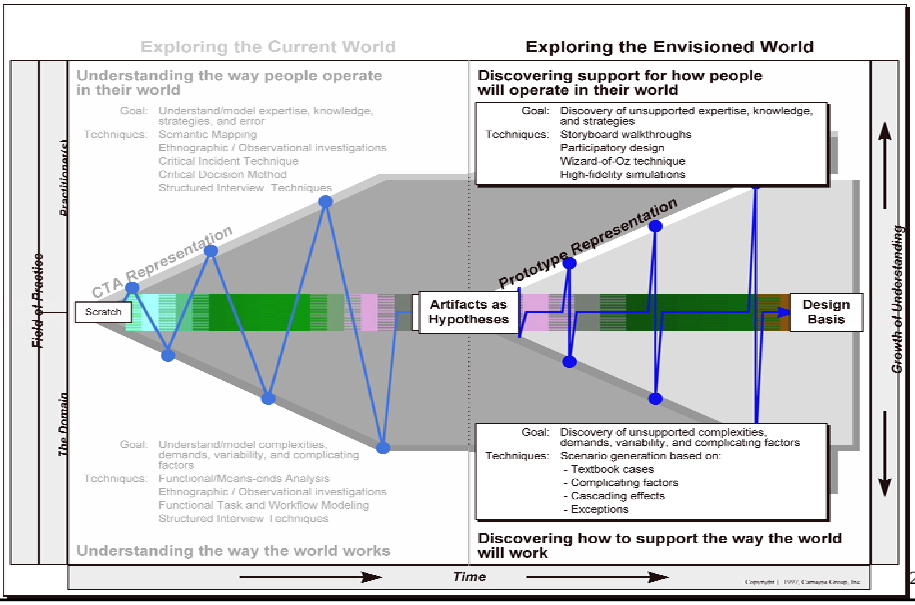
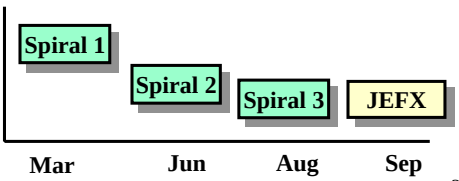


20

JEFX Introduction

Joint Expeditionary Force Experiment: A series of spiral developments culminating in an operational experiment designed to prepare the USAF for the challenges of 21st Century Expeditionary Aerospace Force operations

- **Explores a set of focus areas through spiral development of new systems (technology) and process initiatives**
- **Attempts to anticipate and create future C2 systems based on desired capabilities**
- **Not a laboratory experiment in the classical sense**
  - **Too many new systems**
  - **Many uncontrolled variables**
  - **Designed for process exploration**
  - **Not training or testing**



21

JEFX 2000 Big Picture

Initial Perspective

- Over 2200 Participants at 8 primary locations
- 35 Computer Models/Simulations injecting from different locations
  - Approximately 1200 Sorties/day, 250 messages/hour
  - 241 M&S support & 56 scenario controllers
- Virtual Cockpits (Weapon System Simulators)
  - F-15C/E, F16C, Rivet Joint, JSF, ABL, AWACS
- 77 Aircraft in "live-fly" at Nellis
- 60+ System/Process initiatives

22

Theater Air Control System (TACS)

Joint Force Commander (JFC)

Space Operations

Joint Forces Air Component Commander (JFACC)

Airborne Elements

Air Operations Center (AOC)

Wing Operations Center (WOC)

Control Reporting Center (CRC)

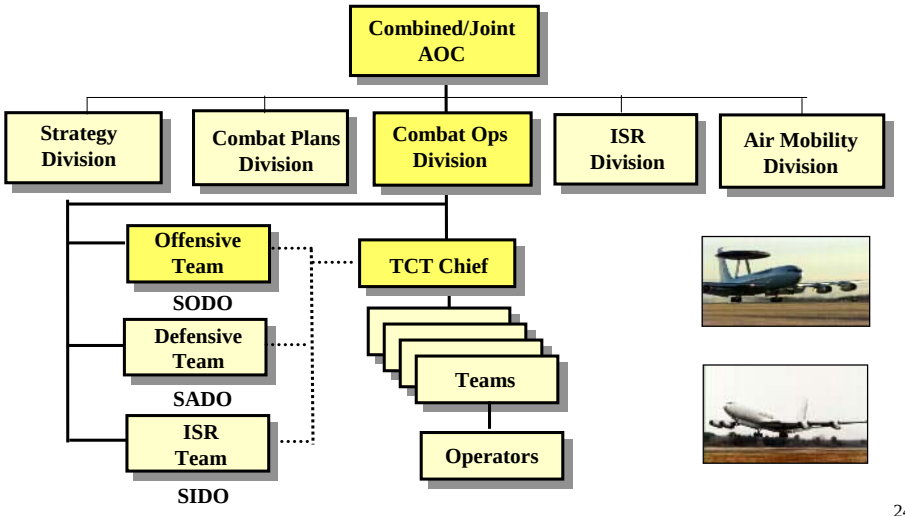
Air Support Operations Center (ASOC)

Control Reporting Element (CRE)

Tactical Air Control Party (TACP)

23

Organizational Relationships



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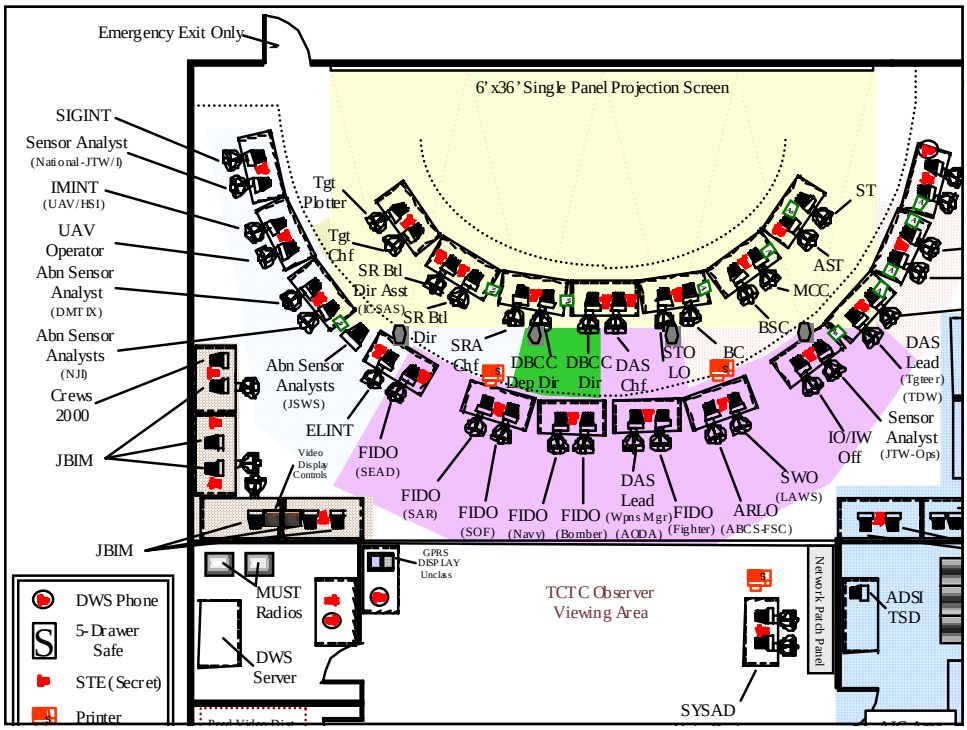
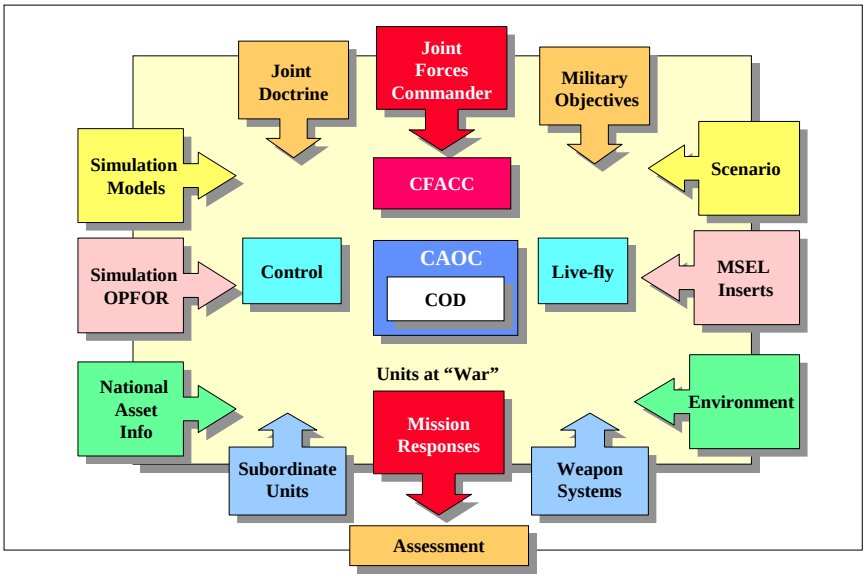
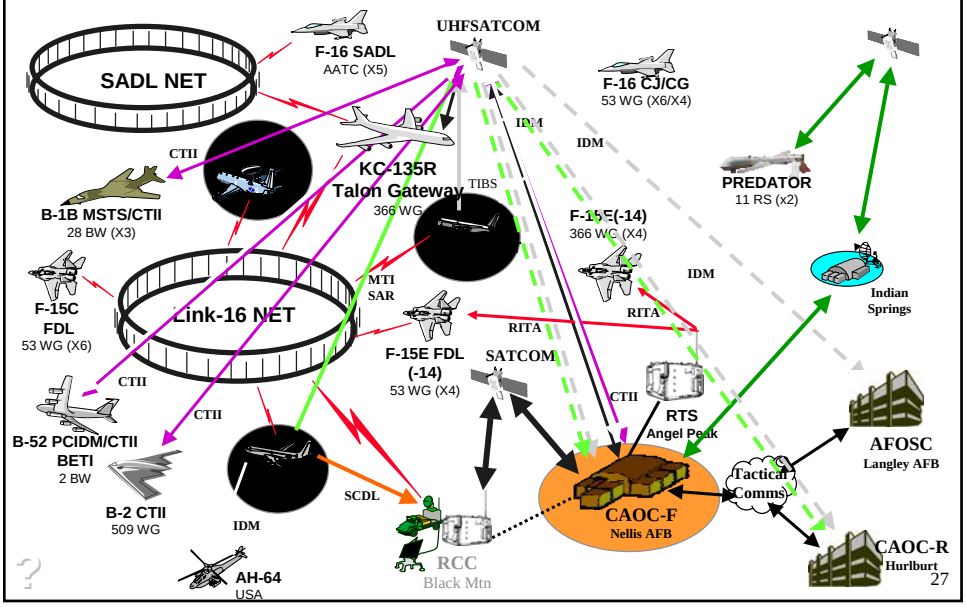


JEFX "Simulation" Environment



26

Time Critical Targeting Cell System Connectivity



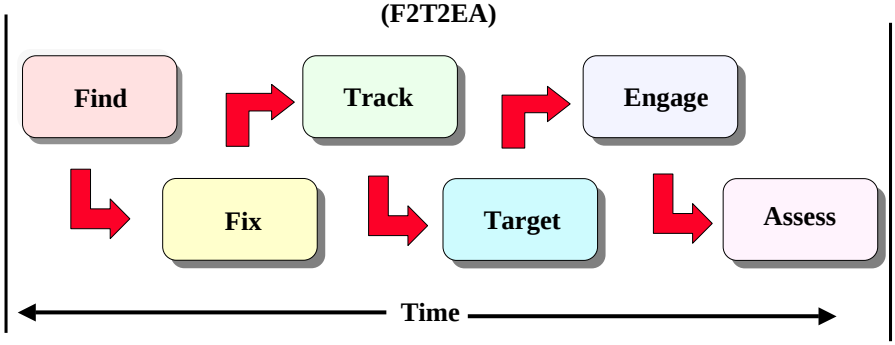
27

Assessments

Organized operations to anticipate TCTs not in the ATO and orchestrate operations to negate mobile surface targets within their operating cycles

Prosecution of Time Critical Targets

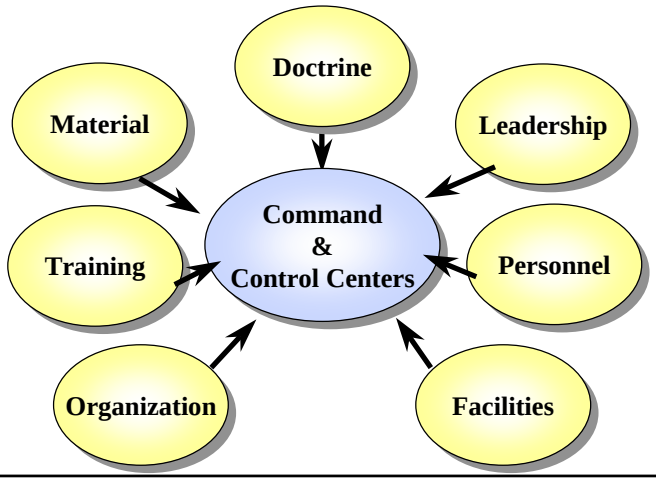
(F2T2EA)



28

Purpose of JEFX Assessment

Identify DOTMLPF recommendations that will improve operational warfighter capabilities



29

TCT Thread

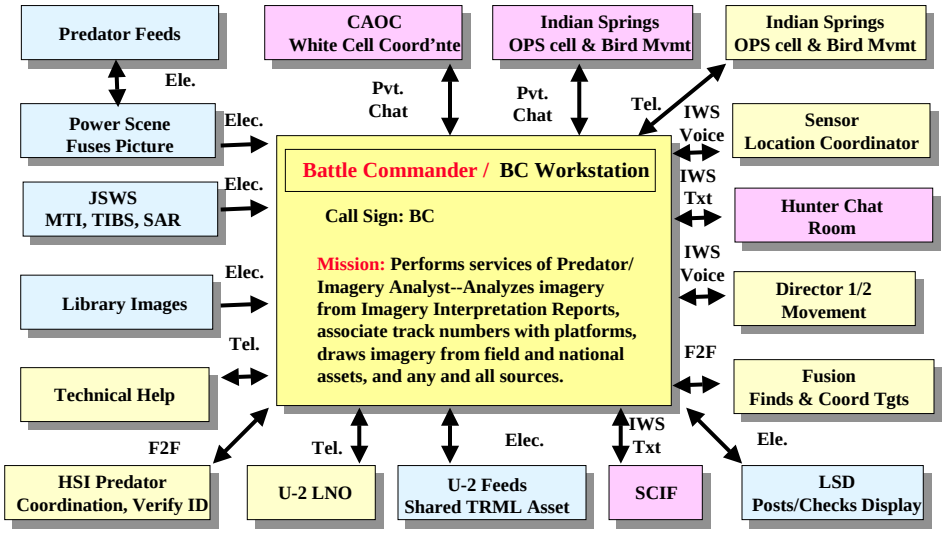
TCT Thread: A group of processes & systems initiatives that work together to support execution of Time Critical Targets

- **Process Initiatives (6)** --New ways of doing business (Doctrine, Organization, Training, Materiel, Leadership & People)
  - Battle Control Center (BCC) JEFX 99 Carryover
  - Intelligence, Surveillance Reconnaissance (ISR)
  - Time Critical Targeting (TCT)

- **System (Technology) Initiatives (70)** --New, existing, or commercial systems to determine operational capability
- TCT Technology Initiatives
  - Talon Gateway
  - Mission Analysis Tracking (MATTS/ITE)
  - Bomber Enhanced Tactical Interface (BETI)
  - Project Suter
  - Panther Den
  - Attack Ops Decision Aid (AODA)
  - TBMCS/Army BCS Interoperability

30

Battle Commander Workstation Connectivity



- Directs movement of the predator by positioning pointer, Has 15 Input/output commo ports

31

Example AFRL/HEAI Message Transmission Capture Form

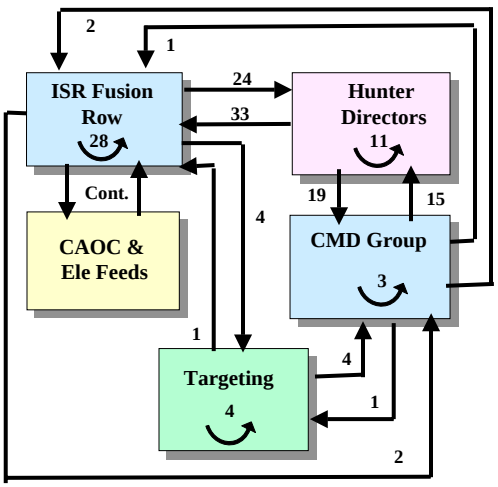
Collector: _Garrambone____ Date___6 Sep 2000_ Start _1759_ End _2200___Page _1__of __8__
Cell/Section ____Hunter____ Physical Location __Director 1 corner___ Episode___ Day 3_____

	Time Zulu	Mode Type	From	To	MSG Gist	RFI	Coor	Ord	Up Date	Res/ Conf
1.	1757	C	HL	All	Radio Check (All come up)	x				
2.		C	D2	All	Set up map—prepare symbology			x		
3.		C	HL	Tgt	Is your radio working					x
4.	1800	C	D1	SCIF	Is your radio working					x
5.		C	D2	All	Reporting downed crew member—CSAR Mission					x
6.	1801	C	Rvn	All	JSTAR in AO		x			
7.		C	D1	All	Focus on two possible targets			x		
8.	1802	C	D2	Sen	Provide ISR asset status check	x				
9.		C	JBIM	D1	Radio check		x			
10.	1803	**F**	HL	BDA	Coordination		x			
11.		**F**	D2	D1	Note 4 targets on screen—remove these two				x	
12.	1804	C	D1	Img	Are these tgts from yesterday?	x				
13.		**F**	HL	TCTC	Coordination					
14.		**F**	D2	D1	Showing too much detail in grid box		x			
15.	1807	C	D1	HL	Too much detail and indistinguishable colors		x			
16.		C	Rvn	D2	I've determined tracks on two tgts				x	
17.	1808	C	Fus	D2	Screen clears when transition takes place		x			
18.	1809	C	Sen	HL	Provide information	x				
19.		**F**	HL	Sen	Coordinating information		x			
20.		C	D2	D1	Status of SA-10 in listing column of data?	x				

R = Radio Trans/Rec; L = Large Screen Display; D = DIS Net; T = Telephone
B = IWS BBS; A = IWS Audio; T = IWX Text; C = 16 channel phone
F = Face-to-Face; P = Person-to-Person; S = Sneaker Net; PA = Public Address
Ord = Order; Res/Conf = Response/Confirmation; RFI = Req for Information; CB = Crib sheet

32

Example Hunter Section Voice/Visual Message Traffic



Direction	Number
CAOC-ISR	Cont
ISR-CAOC	Cont
ISR-CMD	3
CMD-ISR	2
ISR-Hunt	24
Hunt-ISR	33
ISR-TGT	1
TGT-ISR	4

	ISR	Hunt	TGT	CAOC	CMD
ISR	28	24	1	C	2
Hunt	33	11	6	2	15
TGT	4	10	4	0	1
CAOC	C	2	0	?	?
CMD	2	19	4	?	?
Total	67	66	15	2	18

Note. 168 messages caught

33

Communication Forms & Ports

System Feeds

- JSTARS
- VSTARS
- JTIDS
- Predator Images
- Predator Library

Audio Products

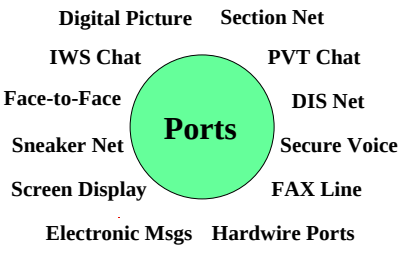
- 16 Pipe DIS Net
- IWS Audio
- Public Addr Sys
- Telephone
- ACCESS Comm
- Sneaker Net
- Secure Telephone
- Face-to-Face

Electronic Products

- TBMCS SAA/ATT
- SPINS & IPB
- SAA Display
- SOLIPSIS Display
- TG / RPTS
- Section Chats
- AODA

Paper Products

- Smart Pack 1
- Smart Pack 2
- Smart Pack 3
- Operator Checklist
- Threat Sys Hndbk
- Operation Hndbk
- Written Msgs
- Coord Cheat Sheets



Special Products

- Large Screen Display
- Private Chat Rooms
- Secure FAX
- OPS Briefings
- SA Briefings
- Pilot Debriefings
- Tools/Apps Briefings
- On-call support
- Computer Crossovers

34

Team Work Observations

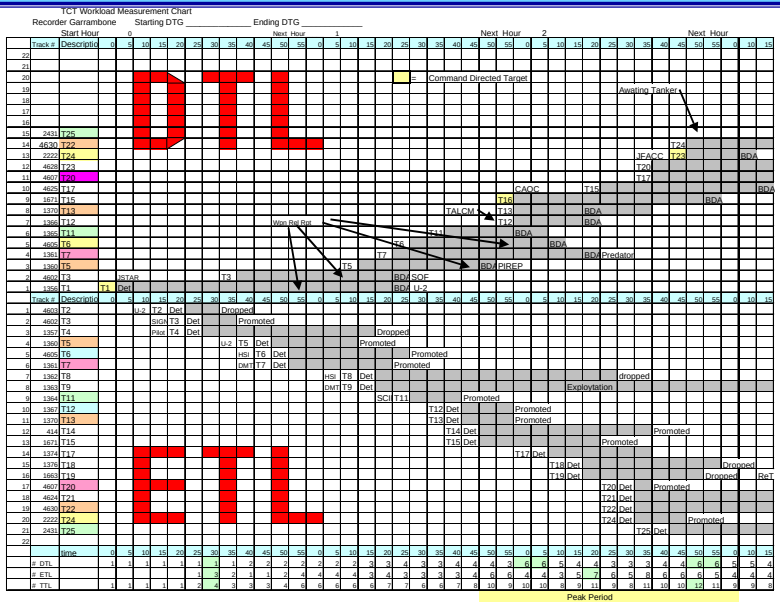
- TCT Cell Ops
- Section Reviews

- Internal Process Review
- Shortfall Analysis
- Operational Discussion
- Team Innovation
- Process Adaptation

- Cross-talk
- Sneaker-net
- Display alerts
- Fusion Nodes
- Task partitioning
- Task sharing
- Info pull/push
- Cohesion meetings
- Definitions
- Documentation
- Questions/agreements

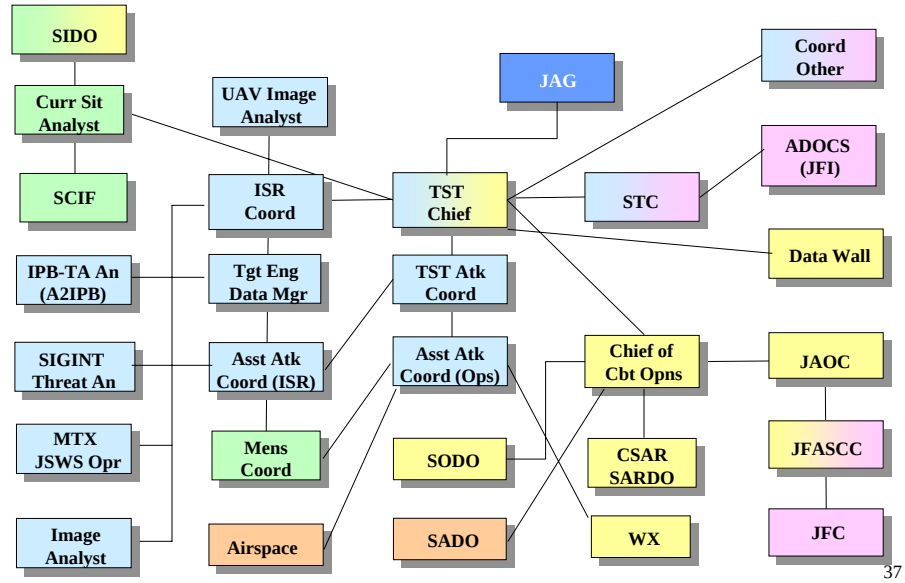
35

Example TCTC Work/Target load Chart



36

JEFX 02 Cbt Ops TST Functional Diagram



37

Human Element Implications

- Evolving C2 Centers present dynamic challenges
- JEFX - good venue to gain Human Factors insights
- New technology / forms of automation - pros & cons
  - Operators reverting to "tried" and "true" when automation failed
- New technologies and processes necessitate new methodologies and processes for operator training
  - New mindset
  - Big picture, consequences, multiple qualifications, etc
- Individual operator and team development implications
- No more pick up teams - well honed and integrated
- Human element requires at least equivalent attention / emphasis as technology and process acquisitions
- Lots of unmade charts (time sensitive to CSAF De-briefings)

38

Summary Training Observations

- JEFX participants recognized the need for more, better training
- Operational training on new systems was critical to the success of TCTC
- Training shortfalls generated need for numerous workarounds
- New-essential training took place every day
- It was requested by operators, was formal and informal, and practiced as a result of the pressure of the operations
- Combat operations require C2 training on numerous subjects to provide error free rapid performance at critical times
- Training has to create the image of "doing it right" in the mind of the operator

39

JEFX 04 Assessment

C2ISR at the tactical level

The work of the Air Control Squadron

40

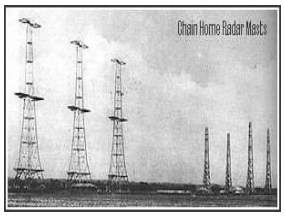
133d Test Squadron

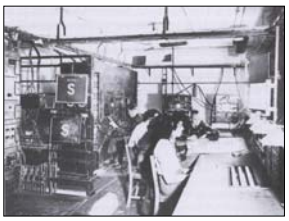
Warfighter Training Research

Warfighter Mission Training

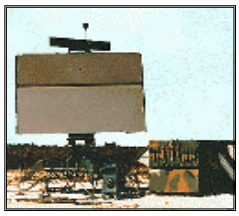
41

Missions of the Air Control Squadron (ACS)





"Battle Management Command and Control"



- Air Battle Management
- Surveillance
- Combat Identification
- Weapons Control
- Data Link Management
- Theater Missile Defense

"Centralized Control and Decentralized Execution"

42

Premise for BCC-X

The Transformation of CRC (MCE-Equipped) to BCS (Future-Equipped)

Present	Transformation	Future
MCE Equipped CRC	Designed- Field Tested Equipped BCC-X	Future Equipped BCS-M
Capabilities now		Capabilities Future

Analysis — Applications of Science, Engineering, Technology, and new TTPs

43

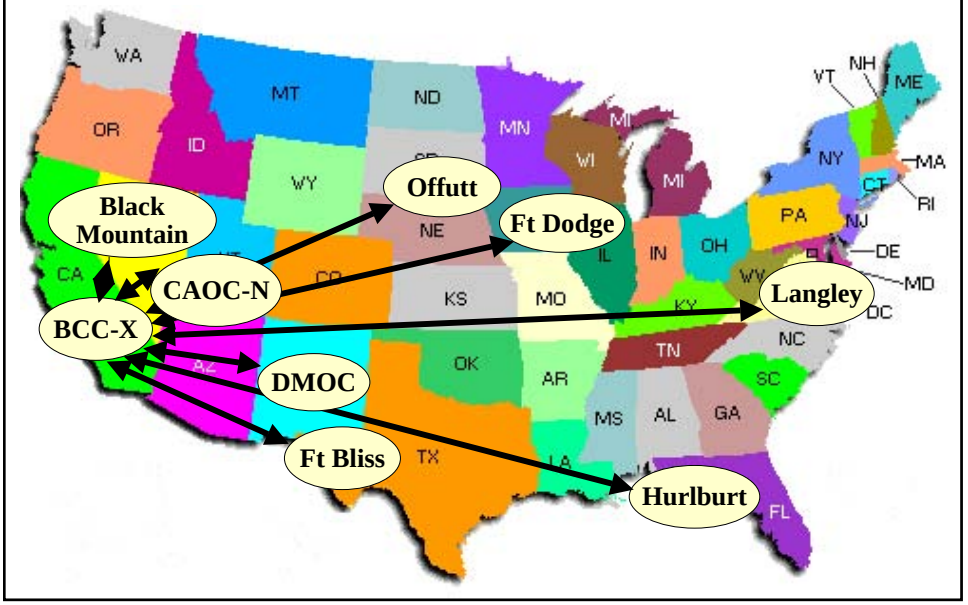
Reasons for Transformation

Defining the BCC-X New Systems

Generic System	Some Example Systems
Situational Awareness System	TDF-like, Thales/Raytheon-like, X-like
Intelligence Information Fuser	Multi-Source Correlator Tracker, other correlators-fusers
Mobile Operations Facility	OMs, GP Med Tent, 3-in-1 Shelter, Temper Tent
Environmental Control Units	600 BTU, 660 BTU, etc.
Communications Radio Systems	AVTEC, ASTI, others
Air Defense Warning/track Sys	TAD MTS, ADSI, SIS
Data Links, Networks, Flows	SATCOMs, Remote Radio, Satellite, BUG-E
Mobility Systems	Mobilizers, M913 Bridge Trucks, S&T Trailers
Robotics Sensors	UCAV, Predator Feeds, GH, SWARM

45

A Distributed Experiment



BCC-X and RCC Locations

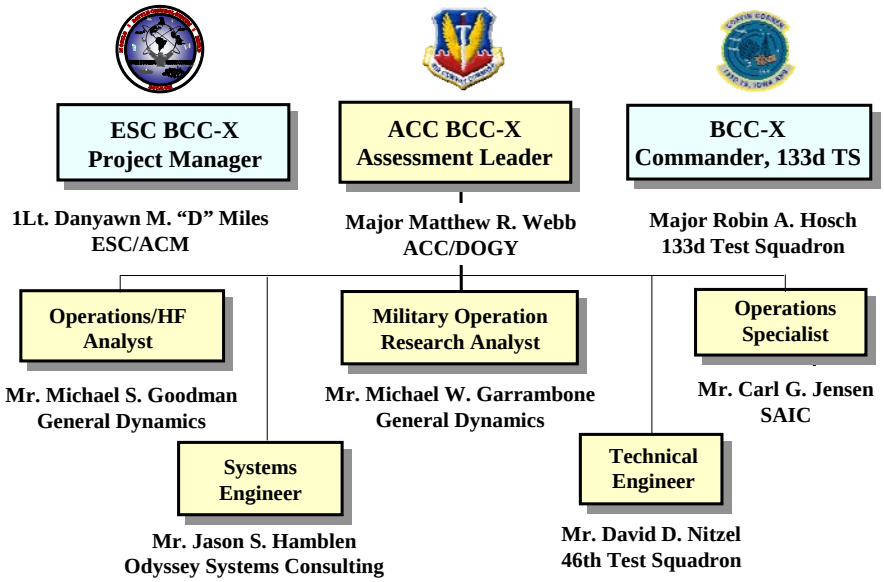
47

BCC-X JEFX 04 Assessments

Types of Analyses for Assessment	Target of Analyses
System Analysis of BCC-X Systems	Devices/systems
Operations Analysis of Processes	Operators
Operational Assessment	Mission
Operational Utility Assessment	Warfighter value
Engineering Technical Assessments	Specifications
Performance Measurement	Baselines
Human Factors Assessment	HF Operations

48

BCC-X Assessment Team



49

Operational Equipment Comparisons

Four Operations Modules

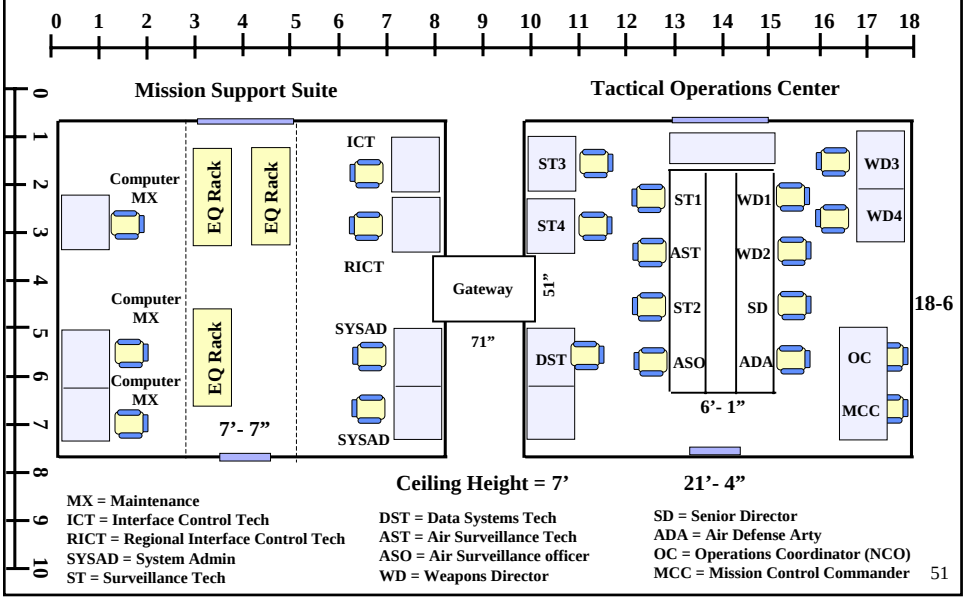
WT. 18K Lbs x 4 = **72,000** Lbs
SF. 4 sections + **4** Mobilizers
16 Operations Consoles
8 ECUs 600 Lbs= **4800** Lbs
SF 2x3x8 = **48** SF Area

Two 3-in-1 Shelters

WT. 15K lbs x 2 = **30,000** Lbs
SF. 2 sections + **2** Mobilizers
16 Operations Consoles
4 ECUs 700 Lbs= **2800** Lbs
SF 3x5x2 (stacked) = **30** SF Area

50

JEFX04 BCC-X 3-n-1 Shelter Configuration



MX = Maintenance
ICT = Interface Control Tech
RICT = Regional Interface Control Tech
SYSAD = System Admin
ST = Surveillance Tech

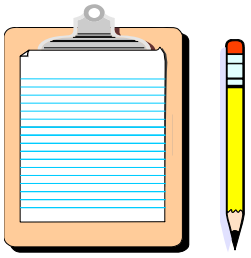
DST = Data Systems Tech
AST = Air Surveillance Tech
ASO = Air Surveillance officer
WD = Weapons Director

SD = Senior Director
ADA = Air Defense Arty
OC = Operations Coordinator (NCO)
MCC = Mission Control Commander

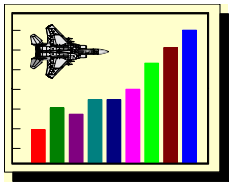
51

Information Capture

- Literature & documentation reviews
- Structured interviews
- Operator daily surveys
- Spot and activity reports
- Player's general observations
- Ops planning meeting extracts
- Solicit thoughts, ideas, & opinions
- De-brief, hot wash & post-ops results
- Electronic data capture (some)
- On-station observations
- Reviews and final comments



Tactical Command and Control Over Time

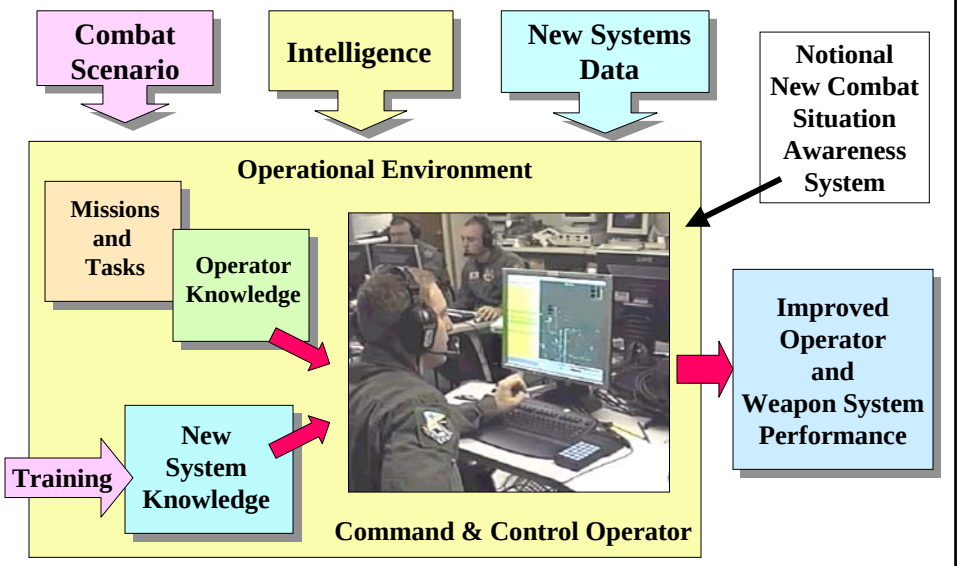


52

Life as an Observer

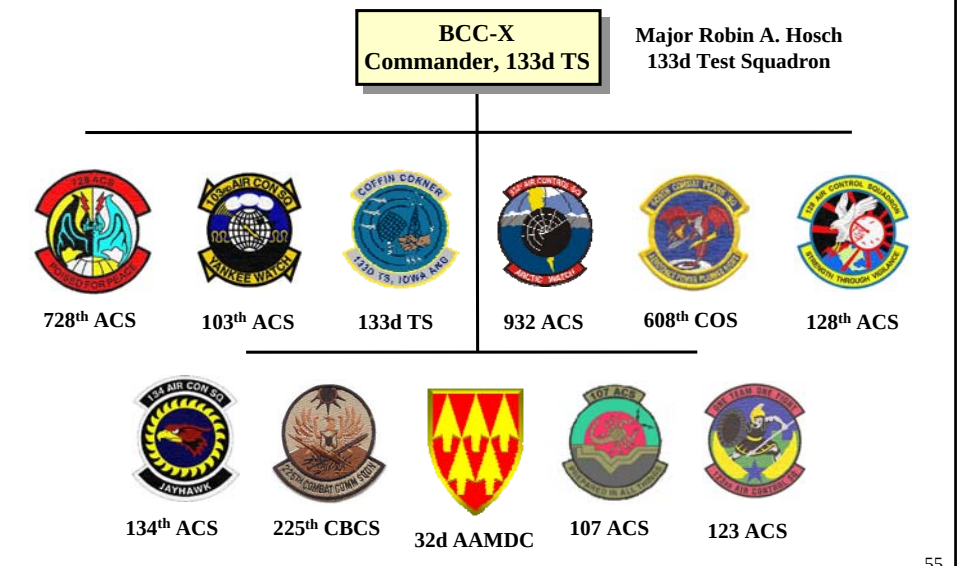
53

Training Research Perspective



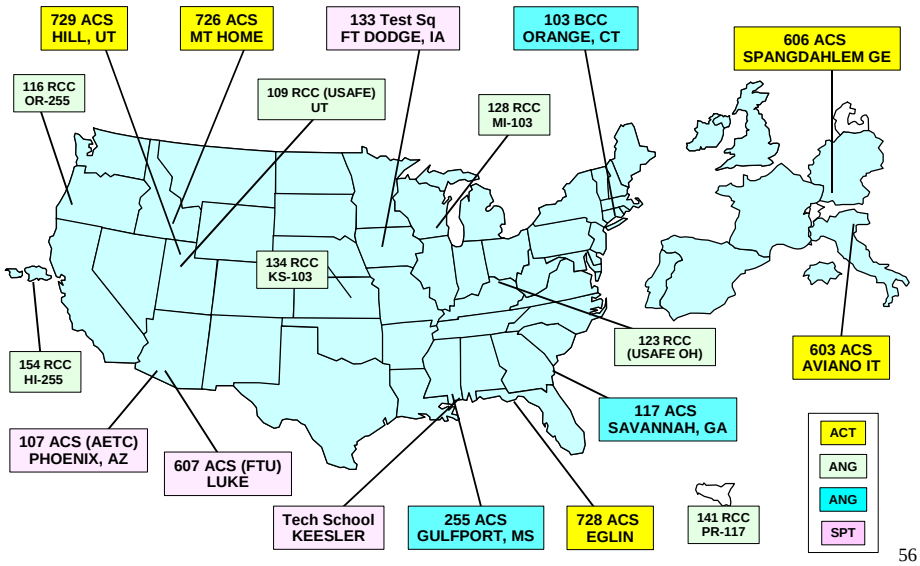
54

JEFX 04 BCC-X Air Control Team



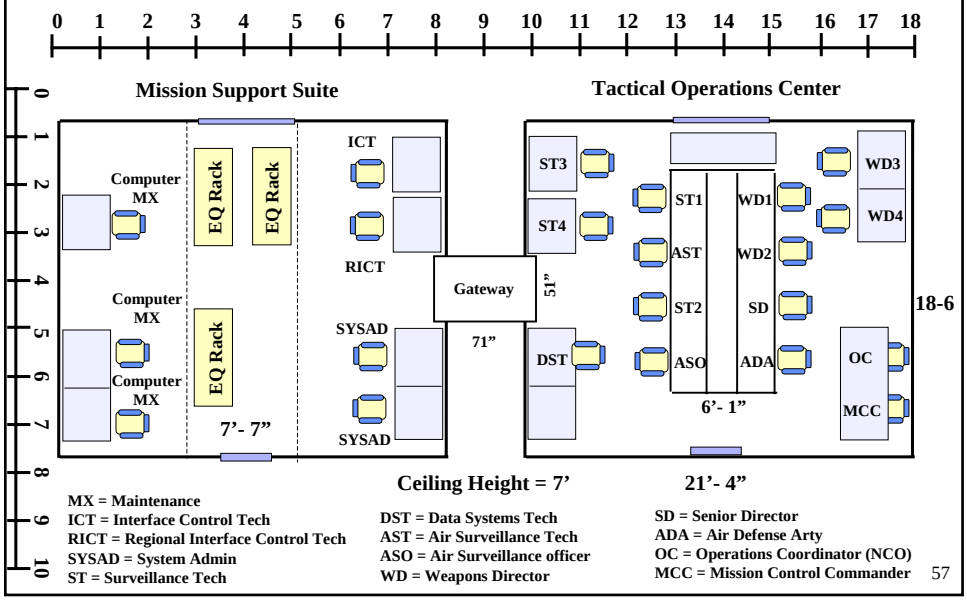
55

ACS Force Structure



56

JEFX04 BCC-X 3-n-1 Shelter Configuration



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WD = Weapons Director

SD = Senior Director
ADA = Air Defense Arty
OC = Operations Coordinator (NCO)
MCC = Mission Control Commander

57

BCC-X to AOC Connectivity

SATCOM

Live Range Radar Data
Live TPS-75 Radar Data
Link-16 RF – T1

CAOC N

DIS Voice (speech)
DIS Data (sim)
IWS Text (msg)

Socket J (Router, TCPIC)
Serial J (Dial-up, RS232)

NIPR/SIPR Net
DSN: Voice, phone
VOIP (speech)
STE Voice

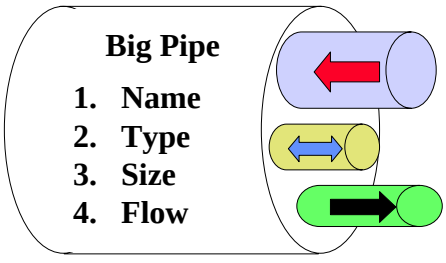
BCC-X

58

Network Connectivity

The Story of the Pipes

There are Pipes within Pipes



Have Now

Still Need

Some Pipe Characteristics

1. Name
2. Type
3. Control
4. Flow medium
5. Size
6. Flow material
7. Inner pipes
8. Format
9. Flow rate
10. Flow direction
11. Flow capacity
12. Status
13. Calibrated
14. Start point
15. Branches
16. Linkages
17. Pumps
18. Drives
19. Flow from
20. Transitions
21. Filters
22. Flow to
23. Mix content
24. End point
25. Security
26. Recorded

59

Recommended CRC Operational Structure (add to AFI 13-1AOC, Vol. 3)

Command Post (CP) or Unit Command Center (UCC)
Battle Commander (1)
Director of Operations (Alt BC) (1)
Director of Maintenance (1)
NCO Operations Coordinator (2)
5

Combat Support Section
System Control (1)
Maintenance Control (1)
Site Support (1)
Force Protection (1)
Civil Engineer (1)
*Disaster Preparedness (1)
6
* Wartime Authorization)

Combat Operations Section
Mission Crew Commander (1)
NCO Battle Staff Coordinator (1)
(Times three-shifts)
2

Mission Planning Cell
Mission Crew Commander (1)
Air Surveillance Tech. (1)
Weapons Director (1)
Intel Officer/NCO (1)
(Times two-shifts)
4

Weapons Section
Senior Director (1)
ADAFCO (only 1)
Weapons Director (4)
6

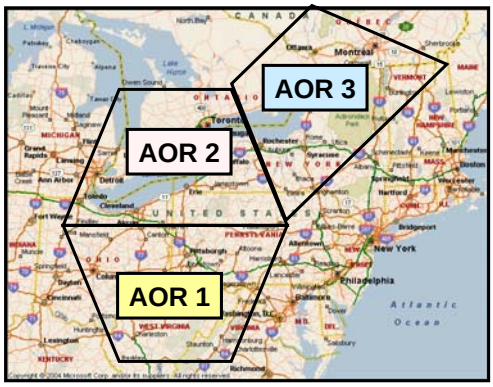
Surveillance Section
Air Surveillance Officer (1)
Air Surveillance Tech. (1)
2

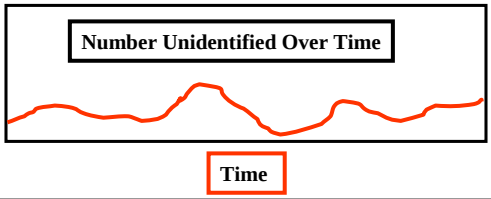
Data Link Team
Regional Interface Control Tech. (1)
Interface Control Tech. (1)
Data System Tech. (1)
3

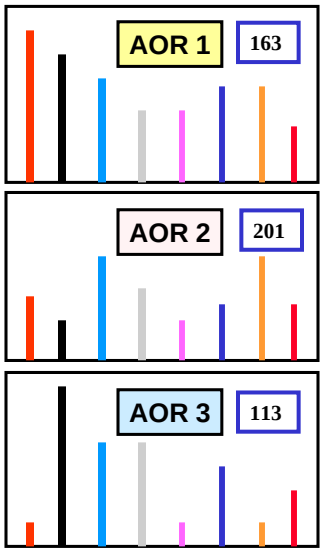
Surveillance Team
Surveillance Tech. (4)
Electronic Protection Tech (2 in DRs)
6

60

Notional Example: AOR Activity







61

Some JEFX 2004 Products

Providing a scientific approach & quantitative response to the assessment process

- Designed schema and definitions for BCC-X processes
- Measures of merit, and data collection forms for information
- Communication diagrams (paths, patterns, message types, rates) outlining internal & external relationships of section/individual station operators
- Operator communications, RFI, coordination, directive orders, information updates, and decision making responsibilities
- Warfighter information, "workload" rates, targets prosecuted, command interest operational displays
- AFEO assessment reports, numerous observations, and comments on operations and leadership
- 325 plus page BCC-X at JEFX 04 Report

62

Lessons Learned JEFX 04 Assessments

- They are optimistic warriors
- They are loyal to a fault
- They don't know "how much"
- They don't know "how long"
- Learn mostly from OJT
- They use rules of thumb
- They are weakly trained
- No automated data capture tools
- No bench marks on performance
- Need technical SMEs to assess
- Operators suffice (good enough)
- They are "minimize" learners
- They use old process w/new tool
- They circumvent the tools
- All Info has a quality index
- They might talk, but don't write
- Experience counts most
- They can't type very fast
- They don't recognize "tired"
- Units need to experience experiments

63

POC Information

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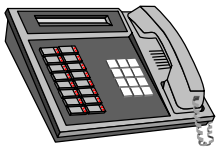
Mr. Thomas C. Hughes



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64